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In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

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Signed

Dated 19 March 2004

Patents Form 1/77

Patents Act 1977
(Rule 16)

04APR03 E [illegible]-2 [illegible]
P01/7700 0.00-0307729.4

1/77

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

NIS/LMS/39709

2. Patent application number
(The Patent Office will fill in this part)

0307729.4

3 APR 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

TESLA ENGINEERING LIMITED
Water Lane
Storrington
Sussex RH20 3EA

Patents ADP number *(if you know it)*

7015571001

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

MANUFACTURE OF SHIM WINDINGS

5. Name of your agent *(if you have one)*

fJ Cleveland

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

40-43 Chancery Lane
London WC2A 1JQ

Patents ADP number *(if you know it)*

07368855001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	1
Abstract	- DL
Drawing(s)	4+4

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature fJ Cleveland — Date 3 April 2003

12. Name and daytime telephone number of person to contact in the United Kingdom — Dr N I Smith — 020 7405 5875

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

MANUFACTURE OF SHIM WINDINGS

This invention relates to the manufacture of coils for use in magnetic resonance imaging spectroscopy (MRIS).

Magnetic resonance imaging and spectroscopy (MRIS) systems generally comprise a plurality of cylindrical concentric coils which are located around a region within which a patient can be located. The coils include an outermost DC coil which is used to provide a strong constant magnetic field, an inner radio frequency (RF) coil arrangement which is arranged concentrically within the DC coil and a gradient coil assembly which is located between the RF coil and the outer DC coil. The gradient coil assembly is arranged to generate a time-varying audio frequency magnetic field which causes the response frequency of the nuclei of the patient to depend upon their positions within the field. The coils which generate the strong constant magnetic field are generally super-conducting coils. The presence of a patient in the magnetic field may distort the main magnetic field making it insufficiently uniform for imaging or spectroscopic measurements. A known way of counter-acting this effect is by providing multi-turn electrical windings known as shim coils and driving DC electrical currents through those windings. A typical high performance MRIS system may contain 8 to 12 shim coils, each of which is arranged to correct an

inhomogeneity with a particular spatial form. The shim coils can also be used to correct intrinsic inhomogeneities of the super-conductive magnet itself.

It is common practice to incorporate shim coils within the structure of the actively shielded gradient coil assemblies which are switched rapidly on and off in a precisely timed sequence to generate MR images. The gradient sequence contains a range of frequencies from zero to 10 kHz or more and this is often referred to as "audio frequency".

Magnets with different geometries are currently being developed and these include what are known as open magnets with bi-planar gradient and shim assemblies. The present invention is applicable equally to these new geometries.

Shim coils can be divided into two classes. The first class is made up of axial shim coils which comprise a series of complete circular turns and which generate axisymmetric field components. The second class is known as transverse shim coils and these include multiple saddle coils which are typically disposed symmetrically on the surface of a cylinder or some other surface. Depending upon the field component to be corrected a transverse shim can typically comprise 2, 4 6, 8 or 12 saddles connected in series with

successive saddles having alternating signs as shown for example in Figure 2 of the drawings.

A number of methods are known for fabricating shim coils. These include photo-etching and winding using insulated conductor. The present invention is concerned with an improved method for fabricating shim coils which is applicable not only to saddle type arrangements, but also to axial shim coils.

According to the present invention there is provided a method of forming an electrical coil which comprises forming the required coil pattern in a sheet of electrically conductive material by cutting or punching. The pattern may be punched from the sheet using a CNC punch or stamping machine. Alternatively, the pattern may be cut using a laser or a water jet. The resulting coil may be a shim coil for use in a MRIS apparatus.

The invention will be described now by way of example only with particular reference to the accompanying drawings.

In the drawings:

Figure 1 is a schematic view of a shim saddle coil formed by the method in

accordance with the present invention.

Figure 2 illustrates how shim saddle coils are arranged in a MRIS apparatus.

Figure 3 illustrates how an axial shim coil can be made, and

Figure 4 illustrates the formation of an anti-symmetic shim coil.

A method of forming a shim coil in accordance with one embodiment of the present invention comprises the following steps. A sheet of solid conductor is partially cut to form the conductor pattern shown generally in Figure 1 of the drawings. This cutting is carried out in such a way that bridges or narrow joins are left periodically between the conductive elements (10) for support. The cutting process can be carried out by a variety of techniques which include punching, water-jet cutting, or laser cutting. In the case of punching, the operation can be carried out using a CNC machine.

The next step in the process is to stick the partially cut pattern onto an insulating backing material. After this step, the bridges or joining portions are cut away in a second cutting operation. Then a further backing layer is added in order to insulate the holes which are formed during the cutting operation

which removes the bridges. Finally the pattern is rolled where necessary prior to assembly and connection.

In order to form an axial shim coil a series of discontinuous arcs can be punched in a sheer of conductive material (Figure 3). The discontinuous arcs can include the bridges referred to above with reference to Figure 1. The sheet is then rolled so that opposite ends are adjacent and continuous arcs formed. The opposite ends can be folded about fold lines (12) so that they are juxtaposed in a radial direction. The coil is then located in an MRIS apparatus and electrical connections move to the juxtaposed end portions.

Antisymmetic shim coils can also be formed as shown in Figure 4. A saddle coil is punched from a sheet of conductive material the saddle extending over more than a circumference. This gives an overlap area (14) where axial circuits are cancelled.

In comparison to coils which are hand wound from insulated strips, the method described above has the following advantages:

1. Repeatability
2. Accuracy
3. Correspondence with theoretical design - no rounding of the corners of

a saddle during winding.

4. Reduced labour and skill.

5. Improved structural adhesion compared to insulated conductor.

6. Comparable mean current density when all forms of insulation are taken into account.

In comparison to the prior art technique of photo-etching of coils the above described method has the following advantages:

1. Reduced cost

2. It is readily scalable to large currents typically of 1 to 10amps.

3. Increased mean current density when all forms of insulation are taken into account.

CLAIMS

1. A method of forming an electrical coil which comprises forming the required coil pattern in a sheet of electrically conductive material by cutting or punching.

2. A method according to claim 1 wherein the pattern is punched from the sheet.

3. A method according to claim 2 wherein the pattern is punched using a CNC punch or stamping machine.

4. A method according to claim 1 wherein the pattern is cut using a laser or a water jet.

5. A method substantially as hereinbefore described.

6. An electrical coil whenever made by a method according to any preceeding claim.

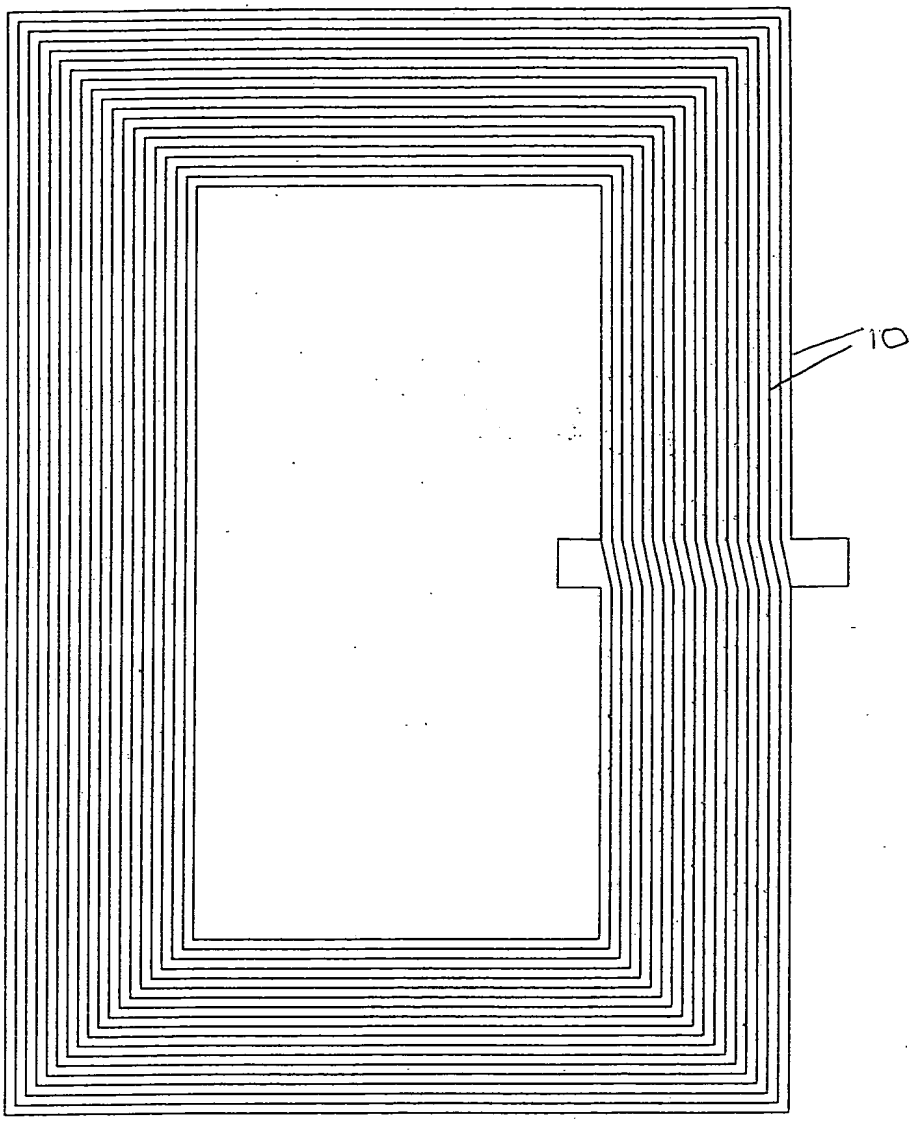

Fig.1: Schematic sketch of a punched shim saddle (one of a set)

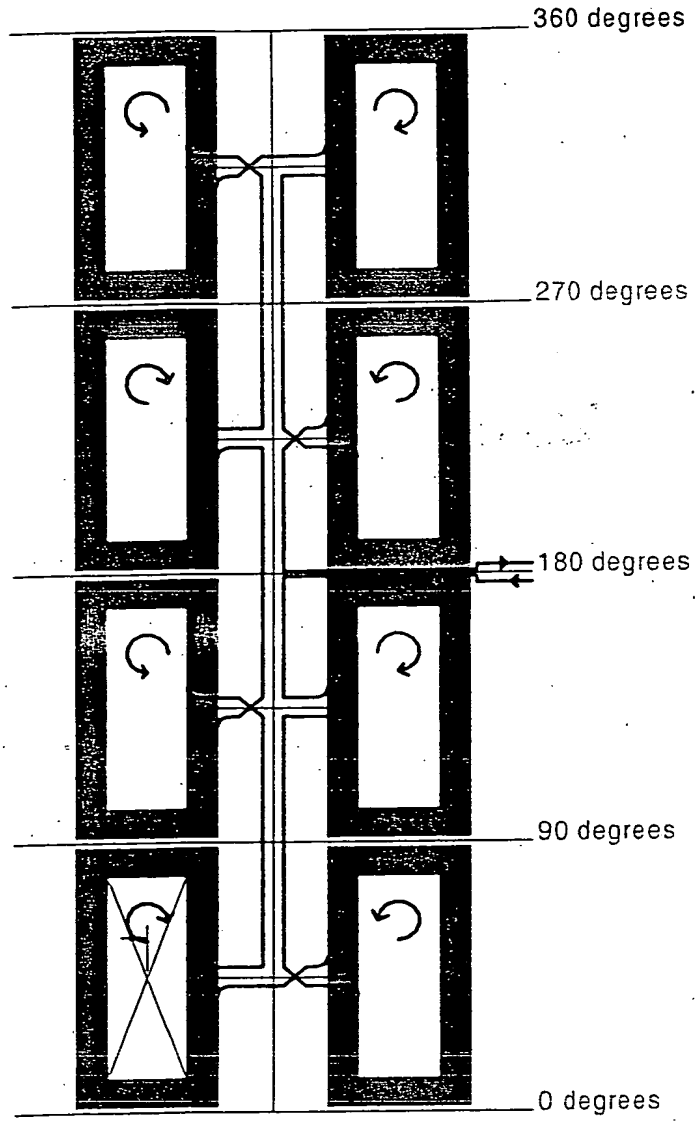

Fig. 2: Example of a transverse shim connection scheme (unwrapped)

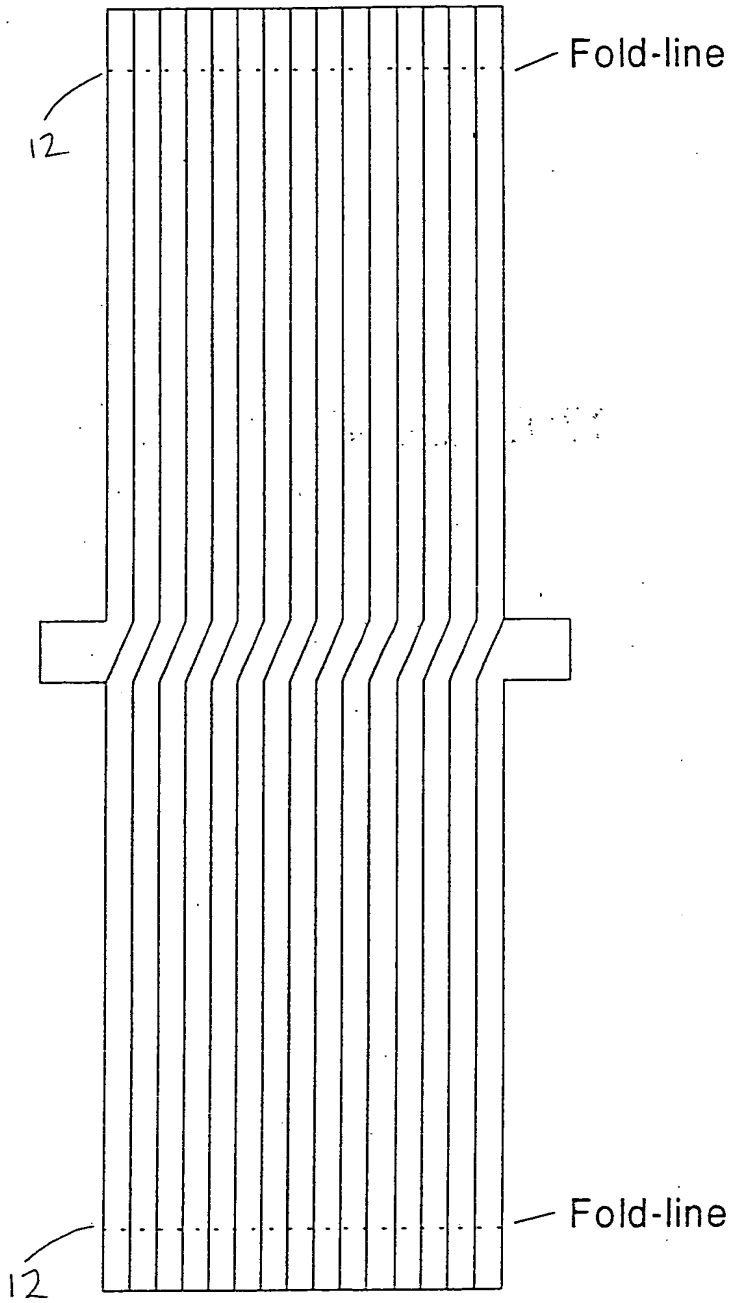

Fig.3

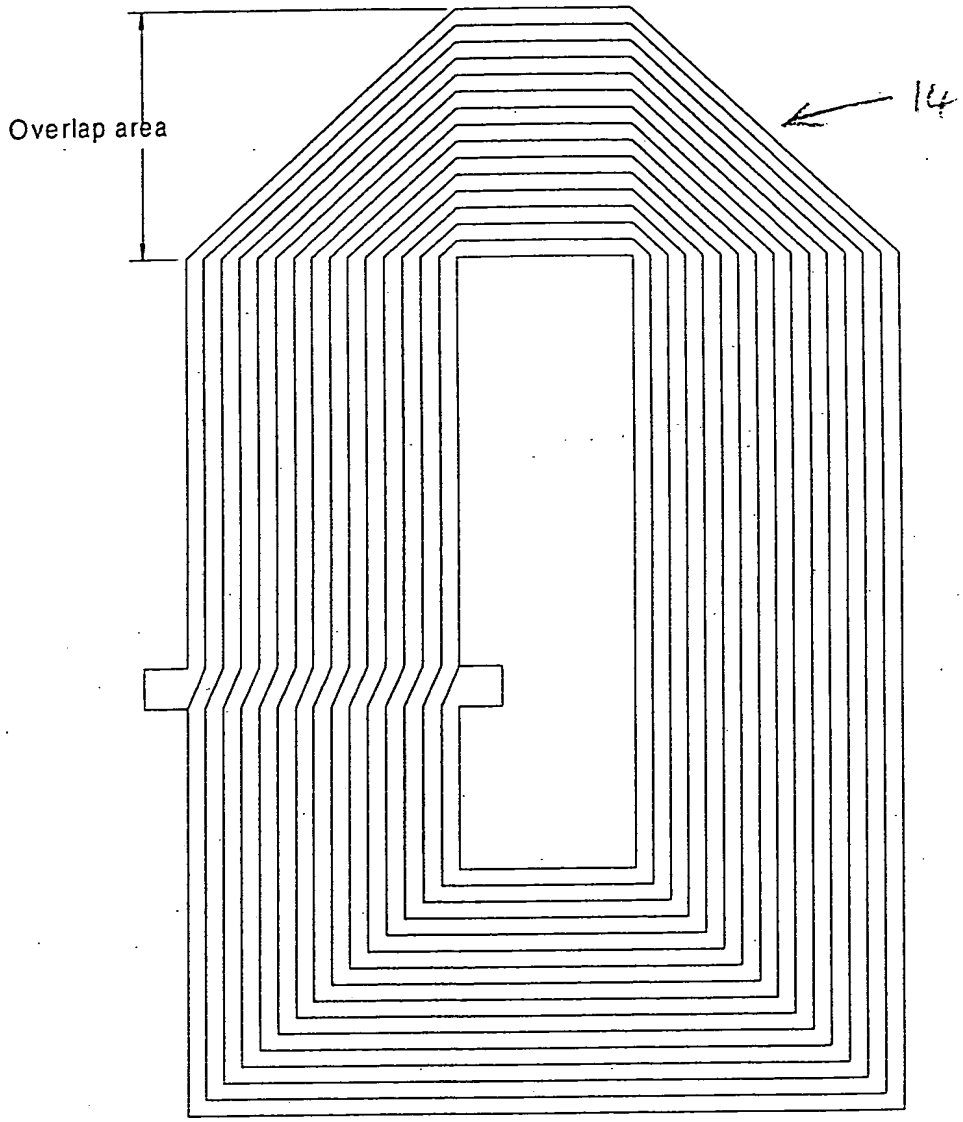

Fig. 4